THE
Engineering In Agriculture
NEWSLETTER

FALL 1999

Earthen Manure Storage Reservoir Seepage Study

Bill MacMillan, ILO Engineer, Red Deer

Peter LLewellyn operating an EM 31 on an earthen manure storage.

For economic reasons, earthen ponds are the most popular method of storing liquid manure produced from intensive hog production. Some concerns have been raised that these earthen manure storage (EMS) reservoirs may leak and contribute contaminants into the groundwater system. Engineering standards exist for many types of earth-based storage structures and these standards are being adapted for use in the agriculture industry. Current research has suggested that manure solids and biological slime films can create an impermeable seal near the soil/manure interface on the bottom and side walls of EMS reservoirs. This seal may effectively eliminate seepage from liquid manure storage ponds constructed into medium or fine textured, clay-based soils. To create the seal, manure solids must infiltrate the soil surface and become entrapped within the soil pores. Besides plugging the soil pore, the anaerobic bacteria that inhabit the manure slurry produce biological slimes that form an impermeable barrier at the soil/manure interface. Laboratory experiments have shown promising results regarding the effectiveness of these seals. However, researchers are unsure if the seal remains intact under field conditions where drying and freeze/thaw cycles may deteriorate the slime layer and cause the soil surface to crack. Depending on their depth, these cracks may provide preferential flow paths for manure leachate to move rapidly into the subsurface.

To answer the questions that exist about sealing and seepage mechanisms in EMS ponds, Alberta Agriculture, Food and Rural Development and Alberta Pork, along with the Prairie Farm Rehabilitation Administration and the University of

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Alberta
AGRICULTURE, FOOD AND RURAL DEVELOPMENT
Engineering Services

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The purpose of this newsletter is to advise of activities and projects being conducted by Alberta Agriculture, Food and Rural Development's Engineering Services and Regional Agricultural Engineering staff. For further information on these projects and other engineering related activities contact:

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Alberta, are conducting an extensive field study. This study is aimed at determining if EMS reservoirs constructed in medium to fine textured, clay-based soils actually leak to any significant degree. One unique aspect of the study is its use of Electromagnetic Induction techniques to detect possible seepage plumes. A previous pilot study determined that GEONICS EM 31 geophysical technology could be used to flag EMS reservoirs that may be leaking. The EM instrument measures soil electrical conductivity (EC) to a depth of six metres. Elevated EC's may suggest subsurface seepage of hog manure since the liquid slurry tends to be highly saline. Where the EM 31 shows seepage, traditional drilling and laboratory analysis techniques are used to validate the findings of the EM investigation.

Potential sites for the study were selected using a Geographic Information System (GIS) based analysis. A hog producer database was combined with a digital soil inventory. The list of producers known to market more than 900 hogs per year was matched with the soil data. This provided a first, best guess at the producers most likely to have a liquid manure storage system located on medium or fine textured soils. These producers were contacted to confirm that they have an EMS and to seek their cooperation for the study. Those that agree to be involved will have their EMS screened for seepage using the EM 31. Those ponds thought to leak will be sampled and instrumented using traditional engineering investigation techniques. The EM results will also be used to help design the drilling investigation program, which will include the collection of soil and water samples and the installation of groundwater instrumentation.

Presently, we have engaged 95 cooperators for the study and approximately 35 of these have been screened for potential seepage using the EM 31. Early this fall, the drilling program will begin to validate if seepage is in fact taking place at the four or five ponds flagged as potential seepage sites. Some sites that were shown not to leak will also be investigated to ensure us that the instrument is providing a true indication of seepage. Eventually the information from the drilling investigation will be reintroduced to the original GIS system to confirm that site conditions were as expected during the original site screening procedure.

The expected results of the study are twofold. First, we hope to determine the factors that need to be known to assess the suitability of a site for safe construction of an EMS properly. Secondly, we hope to confirm that the EM 31 can be used to show potential seepage problems on existing manure ponds. This information will help us to develop appropriate site characterization and design standards for EMS reservoirs and confirm the utility of the EM 31 as an effective and inexpensive tool for investigating possible seepage from earthen manure ponds.

Some Water Wells can be Deadly

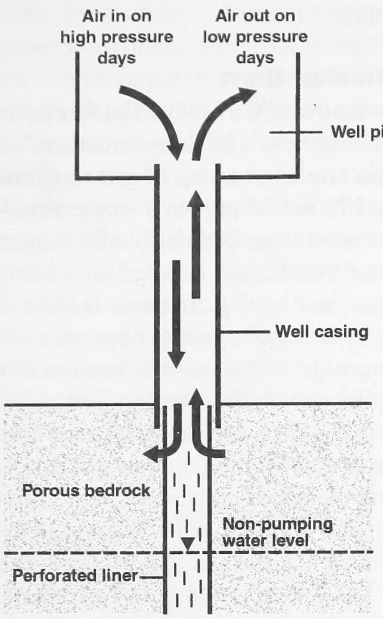
Ken Williamson, Water Specialist, Red Deer

The tragic deaths of two central Alberta teens in July were widely reported in the media as caused by carbon dioxide resulting from the fermentation of rotting vegetables in a root cellar. After the initial media reports, many people have not heard the rest of the story.

When further information came out that the root cellar also served as a well pit it aroused the suspicion of Maurice Lewis, a local well driller and Executive Officer with the Canadian Groundwater Association. He had experience with "suckers and blowers," wells that "breathe" air in on some days and out on others. Some of these wells have been known to take in enough cold winter air to freeze pumping systems as far as 40 feet down the well. No one had really paid any attention to what happened when the well breathed out. This well was one of them, and the consequences were deadly.

Further investigation showed that when the well was breathing out, the oxygen level in the well pit was only 5 percent. It takes at least 19 percent to support life. Carbon dioxide levels were not significantly high, but the nitrogen level in the well casing was 90 percent. When the well was

exhausting air, it could easily fill the pit with this nitrogen (which is colourless and odourless), and cause suffocation. Normal air is 78 percent nitrogen and 21 percent oxygen, so the difference in what the well breathes in and breathes out is significant.



Anatomy of a well that breathes.

These breathing wells tend to take air in when the barometric pressure is high, and out when the pressure is low. No one knows how widespread this phenomenon is, but it is felt that it is the result of air entering and exiting permeable rock formations that are above the non-pumping water level in the well.

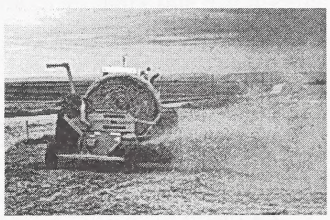
With education, and the upgrading of pressure systems, deaths like these can be prevented. Well pits are also a major cause of well contamination and some have exploded when methane producing wells have been located in them. Well pits were banned when the *Environmental Protection and Enhancement Act* was passed in 1993, but many old ones remain in use. Wherever possible, well pits should be replaced with pitless adaptors and the pits filled in. Information on pitless adaptors is available from Alberta Agriculture, Food and Rural Development Offices, water pressure system suppliers, or well drillers.

Bale Processor Evaluations

Blaine Metzger, Project Technologist, AFMRC, Lethbridge

The trend for larger feedlots has produced a need for larger, faster, more universal and efficient feeding/processing equipment - a demand industry is filling. An interest in the use of bale shredders for bedding material on wind/water erodible soils and for liquid manure lagoon covering in odour control has also increased. Accompanying these interests are questions from farmers/ranchers about the various bale processing/feeding equipment on the market and the different functions available with each processor. In turn, industry has their own questions regarding consumer wants and needs.

Realizing the need to address these questions, the Alberta Farm Machinery Research Centre began researching a variety of bale processors in the spring of 1999. A total of 12 models, brought in by eight different companies, will be tested. Each processor is uniquely different, resulting in a broad range of test results and information. The actual evaluation will run from mid September to the end of October. A report will be written upon completion of the project.

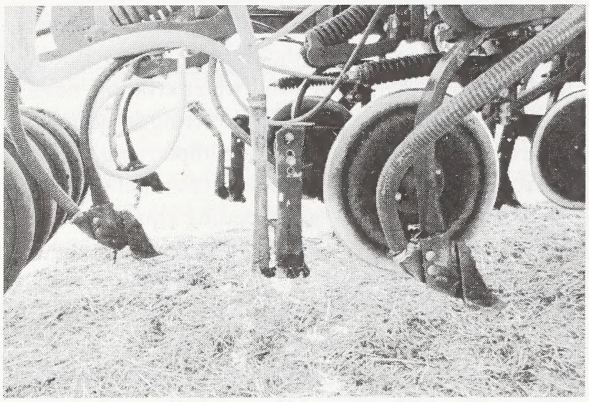


Each of the bale processing units will be operated and evaluated on the following:

- Quality of work - material flow, plugging due to different material types (wet, dry, barley straw, hay, silage round or big square).
- Bale size (round or big square) - time of processing, ease of operation, shredded material size.
- Ease of adjusting and operation - size of shredded material, type of distribution.
- Distance and uniformity of spread.
- Ability to spread material for bedding, windrowing or cover.
- Mechanical history.
- Power requirements.

Nitrogen Placement Project Has Begun

Lawrence Papworth, Project Engineer, AFMRC, Lethbridge



As producers strive for higher crop yields, the demand for more information on openers and nitrogen placement has evolved. This year, AFMRC started a research project to determine the crop emergence and yield differences among the major nitrogen placement systems.

Instead of using specific makes of openers, the study used a coulter to place the nitrogen, and a knife opener to place the seed. The nitrogen systems used were: mid-row band, side placed, sideband, and seed placed. With the seed placed nitrogen system, the seed and fertilizer were placed by the narrow knife. Nitrogen was placed 2 inches to the side of the seed with the side placed system, and 2 inches to the side and 2 inches below the seed with the sideband system. With the mid-row band system, the nitrogen was placed between the seed rows. A 3-inch wide spoon opener was used to place the seed in the mid-row band system. A narrow knife was used with the others. The coulters and knife openers were supplied by Morris Industries Ltd.

Nitrogen type and nitrogen rate were the other variables used in the project. The nitrogen types applied were granular urea and anhydrous ammonia. Nitrogen rates used were 0, 40, 80, and 120 lb/ac. Sites were seeded at Edmonton and Lethbridge.

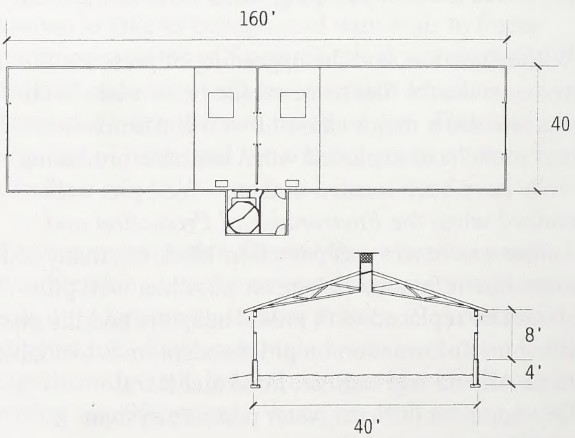
Three Innovative Barn Designs

Robert Borg, Agricultural Engineer, Red Deer

Many standard barn and greenhouse designs do not suit the owner. The opportunity for customization often leads to innovation. Here are three new ideas from central Alberta.

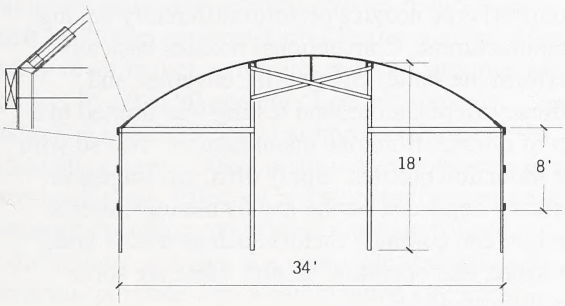
Cole Finisher Barn

A recent innovation in swine finisher housing is the use of "bioshelters" or "hoop structures", buildings that house one large group of grower/finisher pigs, typically 175 to 200 pigs in a single straw-bedded pen. The advantage is their low-cost construction, light metal arch frames covered by a reinforced plastic tarp, and savings in pens, feeders, and waterers by using one pen as opposed to 10 or 15. A disadvantage is that these uninsulated buildings can be quite cool in the winter. To stay warm, pigs must maintain their own comfort zone by making good use of dry bedding, and in extreme weather, increasing their feed consumption. Philip Cole, a producer near Rimbey, Alberta, wanted to combine the advantages of the single pen, straw-bedded shelters with the environment of a conventional insulated, naturally ventilated barn. The end result is a two-pen barn for 500 pigs, with a 250 pigs/pen capacity. This barn has the advantage of being warm in the winter, using normal levels of insulation, and cool in the summer, taking advantage of the natural ventilation. Over the last three years, pig growth and feed conversion rates have been excellent.



Geneva Garden Greenhouse

David Duplane, of Geneva Gardens near Red Deer, wanted to design a low-cost, double-poly covered greenhouse that could be converted to a livestock shelter. He also wanted to use 3/4" fibreglass sucker rods (from the oilfield industry) for the framework. Most of the CAD (computer aided drafting) work involved was calculating the geometric shapes required for the connectors. The outside posts consisted of 2 7/8" drill stem pipe, with a 12" extension welded to the main pipe at a 133.5° angle to accept the end of the sucker rod rafter. Center posts were made from pressure treated wood. The final cross section was 34' wide, with room for 12' bays on both sides of a 10' center alley. Frames are located every 10' along the length of the building, with intermediate supports for the sucker rod rafters placed every 5'. The geometry of this building will accommodate 10' x 12' stalls for future livestock use.

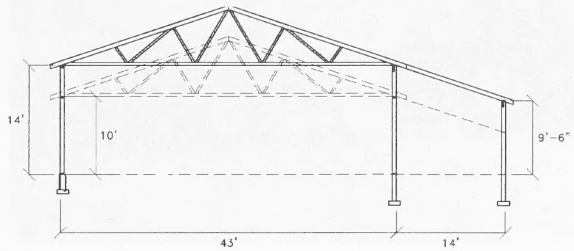


Rufenacht Dairy Renovation

In 1996, Laurenz and Christine Rufenacht of Bluffton, Alberta purchased an older, uninsulated free stall dairy barn. The barn had poor ventilation, excessive condensation in cold weather, no room for a drive-through feeding system, and parts of the foundation were in need of repair. The only solution was a major renovation.

After removing the roof, one outside wall was extended 4' to a total height of 14'. The wall with the poor foundation was replaced with a post and beam system. This wall became the location of the new feed fence. A 14' wide lean-to was added to the side of the barn, allowing a feed wagon to be able to drive the length of the barn. The additional 4 feet of building height allowed sufficient clearance to be obtained in the drive-through alley. The post and beam wall also could be designed for the extra roof load.

To improve the ventilation, a curtain wall natural ventilation system was installed. Rigid insulation placed under the metal roofing, prior to the roof deck being put back in place. Blocking, placed between purlins, has prevented birds from resting on the rafters and damaging the insulation.



Manure Application Research

Blaine Metzger, Project Technologist, AFMRC, Lethbridge

Over the past five years, the Alberta Farm Machinery Research Centre (AFMRC) conducted various research projects in the application of liquid hog, solid cattle, and composted manure on grass and hay. Many organizations are interested in manure applications for increased soil fertility, plant quality, soil structure, and pasture rejuvenation. To accommodate these interests, AFMRC designed, built, and modified a special liquid manure injector and a solid manure spreader. This equipment has proven to be valuable in their research.

A 3-year pasture rejuvenation project began in the spring of 1999, north of the town of Lundbreck. The project compares various levels of liquid hog manure, compost cow manure, and 46-0-0 fertilization, to find the most suitable treatment for pasture rejuventaion. Tracy Dow, the Southern Applied Research Association, the Foothills Forage Association, and the MD of Cypress are cooperators in the project. Forage samples and yields, taken from wire exclusion cages built on the pasture, are being monitored throughout the year. Cattle are grazed on the remainder of the pasture.

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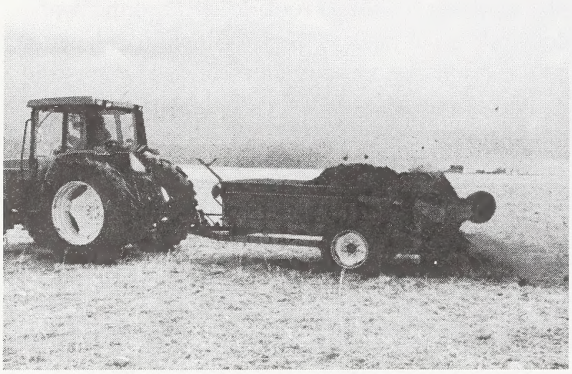
Another study involves applying liquid hog and solid cow manure, at five different rates, twice a year (spring and fall), on an alfalfa hay and timothy grass. Yield, plant quality, and moisture results are collected annually. This 5-year research study is nearing completion.



In the fall of 1998, composted and fresh cow manure were applied on sugar beet land southeast of Vauxhall. Compost manure was applied at three rates and the fresh manure at two rates on one acre plots. The project continued the next spring, with the application of three rates of compost and fresh manure onto potato land West of Vauxhall. Dr. Colin Mckenzie and the Crop Diversification Centre South are participating in the project.

During the spring of 1998, Dennis Laughton and the Foothills Forage Association, in cooperation with AFMRC, set up a pasture rejuvenation project on a five-year-old native pasture near Nanton. Liquid hog and composted lamb manure were applied at 80 lbs/ac of actual N. Various combinations of granular nitrogen, phosphate, and sulphur fertilizer were used in the tests. The intent of this study was to observe the grass response to the various treatments. The grass proved to be quite responsive to the treatments and, some interesting observations were made. For example, cattle ate the grass strip treated with liquid hog manure last, even though the growth was better. These results prompted the next step in the project - measuring grass yield response and the effect of the treatments on plant quality. In the spring of 1999 the same 14 treatments were applied to the pasture. Plots were harvested during the third week of August. Liquid hog manure led the way, yielding 5.12 T/ac, granular urea applied at 120 lbs/ac N was next at 4.6 T/ac, while a blend of 80-60-0-30 placed third with 3.4 T/ac. Compared to the liquid hog manure, the remainder of the applied treatments only produced half the yield or less. The check plots averaged 0.7 T/ac. After harvesting, the cattle were allowed back into the pasture to graze. All plant samples were submitted for analysis. This project will continue over the next few years.

Air Induction (Venturi) Nozzles

Brian Storozynsky, Project Technologist, AFMRC, Lethbridge

Many farmers requested additional tests and information on air induction (venturi) type nozzles. The tests focussed on differences among the various manufacturers' air induction nozzles regarding drift, percent coverage, spray droplet size, etc. AFMRC's preliminary tests, and farmers own visual assessments, quickly showed air induction (venturi) type nozzles perform differently among manufacturers. Conventional nozzles basically perform the same. Spray drift, coverage and efficacy were similar, and testing was limited to a set of nozzles from one manufacturer. Not so with air induction nozzles. Spray drift, coverage and efficacy depended on the nozzle manufacturer's design, and common factors such as nozzle size, pressure, and operating height. Here are some results to date.

The graph compares all air induction nozzles against Turbo TeeJet nozzles at a spraying pressure of 525 kPa (75 psi). The nozzle's operating range evidently became a factor. Air induction nozzles designed to operate at conventional nozzle pressures, between 100 and 400 kPa (15 and 60 psi), reduced drift less than air induction nozzles designed to operate at pressures between 300 and 800 kPa (40 and 120 psi). AFMRC categorized air induction nozzles based on spray drift, under either low or high pressure air induction nozzles. Low pressure air induction nozzles operate best at 275 kPa (40 psi) with an operating range between 100 and 400 kPa (15 and 60 psi). They can be operated up to 500 and 700 kPa (70 and 100 psi) if spray drift is not a concern. These nozzles are well suited for conventional type sprayers with limited pump pressure and where efficacy is a concern. They

include Billericay Farm Systems Air Bubble Jet (ABJ), Greenleaf Technologies TurboDrop XL (TDXL) and possibly Lurmarks Ultra-Lo-Drift. The Ultra-Lo-Drift air induction nozzles are currently being tested by AFMRC.

High pressure air induction nozzles operate best between 400 to 525 kPa (60 to 75 psi). Pressures below 400 kPa (60 psi) are not recommended. These nozzles are suitable for custom applicators that can attain higher pressures. As shown in the graph, drift was still significantly low at pressures above 400 kPa (60 psi). High pressure air induction nozzles include Spraymaster Ultra's (SM), Greenleaf Technologies Turbo Drop (TD), and Spraying Systems AI.

Spray Drift:

Turbo TeeJet (TT) nozzles reduced spray drift by 50 percent over extended range (XR) nozzles. Some air induction (venturi) nozzles reduced spray drift by 90 percent over Turbo TeeJet nozzles. High pressure air induction nozzles reduced airborne drift density by 60 to 90 percent. Low pressure air induction nozzles reduced airborne drift density by 35 to 60 percent. Effect of air induction nozzle size was negligible. Effect of nozzle manufacturer and pressure operating range were more significant. Low volume spraying at a significant reduction in drift was possible with a combination Greenleaf venturi and Turbo TeeJet (TD/TT) tip. However, more research is needed with this combination.

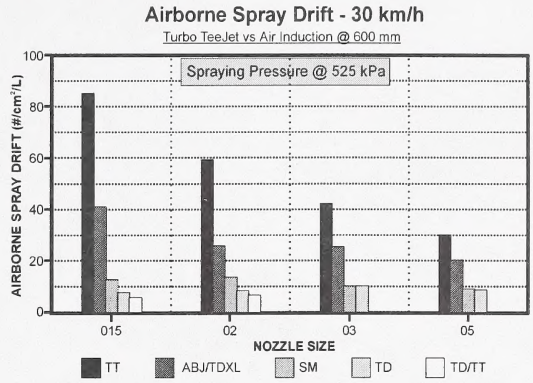
Spray Coverage:

Spray coverage was very good with extended range and Turbo TeeJet nozzles at pressures above 100 kPa (15 psi). Spray coverage was good with high pressure air induction (venturi) type nozzles at pressures above 400 kPa (60 psi). Spray coverage was good with low pressure air induction (venturi) type nozzles at pressures above 140 kPa (20 psi).

Efficacy:

Results mentioned are based on only two seasons work. More research studies are required to determine effects of air induction nozzles. So far, AFMRC has seen no adverse effects in post emergence spraying of cereal crops with air induction nozzles operated at the high pressures.

Expert Committee on Weeds Applications Technology Group cited that chemical products within groups 2, 4, 9 and 22 performed well with air induction nozzles. Within groups 1 and 6, some reduced control was noticed, especially with the high pressure air induction nozzles that produced very coarse droplets or were operated below 345 kPa (50 psi).



New Holland Bidirectional Tractor

Brian Storozynsky, Project Technologist, AFMRC, Lethbridge

Spraying research at the Alberta Farm Machinery Research Centre (AFMRC) has been given a big boost! This summer, New Holland provided AFMRC with a TV140 bidirectional tractor to use in their spraying technology research program.

Sprayers and nozzles are advertised as improving spray deposition and reducing spray drift thereby enhancing efficacy, even at reduced rates. To evaluate these claims, AFMRC built two sprayer frames for mounting the latest in sprayer and nozzle technologies. With so many advances in spraying technology in the past five years, each sprayer frame had to be equipped with five to six different spraying technologies. The TV140, with nearly ten different spraying technologies mounted, made short work of spraying projects this summer. With a mere turn of the seat, the operator was ready to test and operate another half dozen or so spraying systems. This tripled the number of tests carried out this year, as we could spray continuously without changing sprayers.

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The New Holland TV140 has a PTO, 3-point hitch, with hydraulics at both ends capable of handling each plot sprayer. The hydrostatic drive system, with 12.4 x 54 tires, gave the tractor the appearance of a high clearance sprayer, allowing sprayer research to be carried out in row and special crops not normally done. In addition, spraying tests were carried out at 12 to 15 mph to study the effect of high speed spraying, typical among high clearance sprayers. Articulated steering allowed for tight turns common in scientific field studies. The main hydraulic system, with a second independent auxiliary system, operated the numerous sprayer fans and pumps efficiently.

The TV140 tractor has helped AFMRC and producers stay current with sprayer advancements. Interim reports on the effectiveness of the various sprayer and nozzle technologies will be issued at trade shows, agriculture conventions, and seminars throughout the year. A final report will be written when all tests are completed.

Update On Seeding Research

Lawrence Papworth, Project Engineer, AFMRC, Lethbridge

The Alberta Farm Machinery Research Centre (AFMRC) continued work on two seed and fertilizer studies in 1999. One study will determine the effect of row spacing and seeding rates on emergence and crop yields. The other will examine the effect of using liquid and granular fertilizer, at various placements and rates, on emergence and crop yields. Both projects were started in 1998.

Sites chosen for the row spacing project for 1999 were Lethbridge, Blackie, Stony Plain and Provost.

The Barton double shoot angle disk opener was used to seed at row spacings of 8, 10 and 12 inches. Three seed rates were also used in the study. Results from 1998 showed that an increase in row spacing resulted in a decrease in barley emergence. At one site, an increase in row spacing resulted in a decrease in barley yield.

The liquid fertilizer project used four different openers and compared liquid and granular fertilizer. Openers used in this study were: a side band double shoot with 1 in. x 1 in. separation, a side band double shoot with 0.5 in. x 0.5 in. separation, a narrow row hoe single shoot, and a partial ribbon spread single shoot. All the openers were fabricated and supplied by Flexi-coil. Fertilizer rates applied were 0, 40, 80 and 120 lb/ac. Sites for the 1999 liquid fertilizer project were at Lethbridge and Provost. Results from 1998 showed that the nitrogen type did not affect barley emergence. However, the nitrogen type did affect the yield. At one site, the yield was much higher with liquid as the nitrogen source. In most conditions, the narrow opener resulted in lower emergence and yield.

Cooperators for the projects are the Gateway Research Organization, Alberta Reduced Tillage Initiative, and AAFRD. The major sponsor for both projects is the Alberta Conservation Tillage Society, through the Canada Adaption Rural Development Fund. Another sponsor of the row spacing project is the Southern Applied Research Association.